Insurance and Epidemics: SARS, West Nile Virus and Nipah Virus

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Severe acute respiratory syndrome (SARS) reminds us that sudden disease emergence is a permanent part of our world—and should be anticipated in our planning. Historically the emergence of new diseases has had little or no impact beyond a small, localized cluster of infections. However, given just the right conditions, a highly virulent pathogen can suddenly spread across time and space with massive consequences, as has occurred on several occasions in human history. In the wake of the SARS outbreak, we are now forced to confront the unpleasant fact that human activities are increasing the frequency and severity of these kinds of emergences. The idea of more frequent biological “invasions” with economic and societal impacts comparable to SARS, presents stakeholders in and the global economy with unprecedented new risks, challenges and even opportunities. As a major contributor to economic stability, the insurance industry must follow these trends very closely and develop scenarios to anticipate these events.

Mortality rates continue to improve in most parts of the world. However, from time to time, our environment throws us a challenge that causes us to consider whether a new trend has begun. In recent years, the infectious disease threat has diverged considerably from its previous patterns of epidemiology, drug susceptibility, geographical distribution and severity. This divergence has been the result of several factors. The natural behavior of the microbial world is complex and constantly evolving. Where infectious disease agents and vectors are concerned, nature not only takes its course; it also takes advantage of every opportunity to multiply, mutate, migrate, adapt to new hosts and habitats, and evolve to resist drugs and insecticides. The phenomenal growth of international travel and trade has vastly increased the speed and ease with which pathogens and vectors can cross continents to cause outbreaks, epidemics, and on occasion, establish permanent residence in new areas. As a result, new pathogens, or newly recognized diseases involving known pathogens, are being reported at an unprecedented rate. In the last decades of the 20th century, over 30 new diseases—including AIDS and Ebola hemorrhagic fever—were detected for the first time. No country acting alone can defend its borders against this threat. Efficient defense requires a global system for gathering infectious disease intelligence, detecting outbreaks quickly and collaborating to contain their spread.
SURVEILLANCE AND RESPONSE SYSTEMS

Surveillance systems keep the world alert to changes in the infectious disease threat and provide the background data needed to detect an unusual event, whether this involves an upsurge in cases of a well-known endemic disease, the appearance of a previously unknown pathogen or an outbreak caused by the deliberate use of a biological agent to cause harm.

In April 2000, the World Health Organization (WHO) launched the Global Outbreak Alert and Response Network (GOARN)\(^1\) as a mechanism for keeping the volatile microbial world under close surveillance and ensuring that outbreaks are quickly detected and contained. This network links 110 existing networks in real time. These networks possess much of the data, expertise and skill needed to keep the international community alert to outbreaks and ready to respond.

Procedures for alert and response have 4 phases: systematic collection of reports or rumors of new outbreaks; outbreak verification; communication of confirmed facts to selected partners and the world at large; and containment, including coordination of international assistance when required. An innovative tool that gathers real-time disease intelligence supports the first phase. This is the Global Public Health Intelligence Network (GPHIN), an electronic surveillance system developed for WHO in partnership with Health Canada. GPHIN heightens vigilance by continuously and systematically monitoring Web sites, news wires, local online newspapers, public health e-mail services, and electronic discussion groups for rumors of outbreaks. In this way, WHO is able to scan the world for informal news that gives cause for suspecting an unusual disease event.

Six main criteria are used to determine whether an event is of potential international concern:

1. An unknown disease
2. Serious health impact or unexpectedly high rates of illness and death
3. Potential for spread beyond national borders
4. Potential for interference with international travel or trade
5. A nation's capacity to contain the outbreak
6. Suspected accidental or deliberate release

From July 1998 to August 2001, WHO verified 578 outbreaks, of which 56% were initially picked up by GPHIN. These outbreaks occurred in 132 countries, indicating the system's broad geographical coverage. Twenty-two countries, many affected by continuing conflict, had 10 or more verified outbreaks of potential international significance. The most frequently reported outbreaks were cholera, meningitis, hemorrhagic fever, anthrax and viral encephalitis.

Traditionally, one of the main factors undermining the effectiveness of infectious disease surveillance has been the reluctance of countries to report outbreaks out of concern this news would negatively impact travel, trade and tourism. Costs from outbreaks may escalate when reactions are inflamed by sensational media coverage. Widespread and sometimes exaggerated media coverage of the 1994 plague epidemic in India contributed to trade and tourism losses in the range of US $2 billion. Public alarm over the safety of beef, sparked by the epidemic of bovine spongiform encephalopathy, prompted the European Union to introduce a series of very expensive control measures (estimated cost of US $2.8 billion in 2001). With costs of this magnitude, countries with fragile economies are understandably reluctant to report the occurrence of outbreaks that are certain to result in severe economic losses. New forces at work in an electronically interconnected world are beginning to break down the traditional reluctance of countries to report outbreaks. The Nipah virus outbreak and the SARS epidemic are 2 recent examples of reporting delay.

EPIDEMIC AND UNEXPECTED EVENTS

Epidemic-prone diseases, such as cholera, dengue, influenza, meningitis, plague, yellow...
fever and food-borne diseases, pose an almost constant threat to human populations. They are well adapted to human transmission either directly from person to person, through transmission by insects and other disease vectors, or by contamination of food or the environment. These diseases are generally well understood and, in most cases, effective measures are available for their control.

Previously unknown infectious agents that have crossed the species barrier from animal to humans can cause unexpected or unusual disease events. Infectious agents that appear in a new geographical area can also cause unexpected events. Finally, biologic agents that have been deliberately engineered and introduced by acts of bioterrorism can cause unusual disease events. The ability to detect emerging or unexpected diseases depends on sensitive surveillance. Adequate background data on usual disease events in a particular geographical area or under specific climatic conditions facilitate recognition of the unusual.

The appearance of new diseases is unpredictable. Their detection is problematic and they are frequently misdiagnosed, even in the most advanced countries, eg, HIV in the United States and Europe. These new diseases are poorly understood as they emerge and, therefore, difficult to treat and control. When the dynamics of transmission are unknown, epidemics can take a long time to contain. While some emerging pathogens are not well adapted to human populations and lack the potential for sustained epidemic spread, they are frequently associated with high mortality, as they occur in new and often highly susceptible hosts. Examples discussed in this article include SARS, West Nile virus and Nipah virus.

EPIDEMIOLOGY: WHAT DATA DO WE NEED?

Epidemiology is based on 2 fundamental assumptions. First, human disease does not occur at random. Second, systematic investigation of different populations, and subgroups within populations at different places or times can identify causal and preventive factors. Epidemiology defines the who, what, when, where, how and why of infectious diseases. The who is the population at risk for infection. The what is the scope and impact of infections. The when is the temporal trends. The where is the geographic location of the disease. The how defines the reservoirs of disease and the mechanisms of transmission. The why addresses risk factors, or the reasons disease affects some persons but not others.

Descriptive epidemiology involves the collection and analysis of all data that describe the disease in the population. Its main limitations are the under-reporting or the under-ascertainment of cases of a specific disease. The precise number of cases that indicates the presence of an epidemic varies according to the agent, the size and type of population, previous experience or degree of exposure to the disease, and the time and place of occurrence. The identification of an epidemic also depends on the background frequency of the disease in the area in the specified population during the same season of the year, eg, influenza. Even a very small number of associated cases of an unrecognized disease may be sufficient to constitute an epidemic. For example, the first report on AIDS involved only 4 cases of pneumocystis carinii pneumonia in young homosexual men.

The initial stage of investigation should verify the diagnosis of suspected cases and confirm that an epidemic exists. The preliminary investigations also lead to the formulation of hypotheses about the source and spread of the disease, and this, in turn, may lead to immediate control measures. The case definition is an essential step, especially when the cause is not clearly defined. The development of a case definition is an important step that can profoundly affect the outcome of the analysis. For example, a strict clinical case definition may limit the recognized spectrum of disease; whereas a loose case definition may include persons with illness from
an entirely different cause. As with diagnostic

tests in clinical medicine, it would be desir-
able in epidemiology to have a case definition

that is 100% sensitive and 100% specific; how-

ever, this is not realistic. The investiga-
ton of the AIDS epidemic started long before
the HIV virus was identified and was based
on a CDC case definition that was adapted
when new data became available. The main
goal is to label clinical cases and classify them
in a way that allows further epidemiological
investigations.

As an example of a case definition, a sus-
pected case of SARS is defined as document-
ed fever (temperature $\geq 38^\circ C$), lower respira-
tory tract symptoms, and contact with a per-
son believed to have had SARS or history of
travel to an area of documented transmission
(according to the WHO). A probable case is
a suspected case with chest radiographic
findings of pneumonia, acute respiratory dis-

tress syndrome (ARDS), or an unexplained
respiratory illness resulting in death with au-
topsy findings of ARDS without identifiable
cause.

Three closely interrelated components, fre-
quency, distribution, and determinants, en-
compass all epidemiologic principles and
methods. The prerequisite for any epidemio-
logic investigation is the ability to quantify
the occurrence of disease.

The most basic measure of disease frequency
is the simple count of affected individuals.
Such information is essential for public health
planners and administrators who wish to de-
termine the allocation of healthcare resources
in a particular community. However, count
data alone has very limited utility for epide-
iologists. To investigate distributions and
determinants of disease, it is also necessary
to know the size of the source population
from which affected individuals were de-

rived, as well as the time period during
which the data was collected. The availability
of such data is essential for any systematic
investigation of patterns of disease occur-
rence. The use of such measures allows direct
comparisons of disease frequencies between
2 or more groups of individuals.

\textit{Incidence rate} is defined as the number of
times an infection is noted in an observed
population during the defined period divided
by the number of persons observed in that
time. For most infectious diseases, the inci-
dence is reported as an annual rate. For a few
infectious diseases that cause a chronic ill-
ness, it may be more appropriate to refer to
the \textit{prevalence} of disease, the proportion of
the population ill in a defined time period. Be-
cause most infectious diseases have a short
duration, however, the frequency of the ill-
ness is usually given as an annual rate.

The incidence of the disease can be deter-
mained by a variety of methods. Most com-
monly, an illness is declared reportable by
state law, and a formal surveillance system is
established. A crude annual incidence can be
calculated by dividing the number of report-
ed cases by the size of the population. Ob-
served over time, changes in incidence can
identify an emerging problem or the effect-
iveness of prevention or control measures.
Comparing incidences can assist public
health officials in allocating resources, or the
clinician in considering the most likely cause
of a particular syndrome. Comparing inci-
dence of disease in different populations can
provide clues as to how the disease is being
transmitted or indicate the presence of spe-
cific susceptibilities in the population.

The incidence of many infections varies
over time. A \textit{secular trend} is a change in the
incidence of disease over an extended period
of time. A \textit{periodic trend} is a change in the
secular trend that tends to recur at consistent
intervals. Before the widespread use of vac-
cine, measles demonstrated periodic trends in
the United States, with peaks every 2 years.
Most periodic trends have been attributed to
either changes in the organism or changes in
population immunity. A \textit{seasonal trend} is a
consistent pattern in the annual occurrence of
a disease, for example influenza. The expla-
nation for the presence of a seasonal trend is
usually not known but is frequently the sub-
ject of speculation. The assessment of the risk
of recurrence trends of SARS is the topic of
continued debate with no final conclusions.
The second basic measure, the *distribution of disease*, considers who contracts the disease within a population, as well as where and when the disease is occurring. This may involve comparisons between different populations at a given time or comparisons between sub-groups of one population. These comparisons are essential to describe the pattern of disease, as well as to formulate hypotheses concerning possible causal or preventive factors.

A population may be defined by a specific geographic location, host characteristic or exposure. Examples include residents of a county or state, participants in a church supper, children in a daycare center, or patients in an intensive care unit. In different populations, the same infection may have different characteristics, such as incidence, clinical manifestations and mechanisms of transmission. Some infections are grouped by somewhat arbitrary population definitions that make epidemiologic sense, for example nosocomial and community-acquired infections. The hospital is a distinct ecosystem with a self-contained human population, unique pathogens and unique mechanisms of transmission. In the SARS epidemic, hospitals served as powerful centers of disease transmission until containment and quarantine were introduced. The community is a more diverse ecosystem without clear physical boundaries that harbors many different pathogens and many human populations. Populations frequently interact providing ample opportunities for transmission of infectious agents. For example, organisms are often transmitted into the hospital from the community, and vice versa, as seen with SARS.

The third component, the *determinants of disease*, follows from disease frequency and distribution, since knowledge of these is necessary to test an epidemiologic hypothesis.\(^4\) One of the purposes of analytic epidemiology is to identify the risk factors associated with disease. This is typically accomplished by case-control or cohort analysis that attempts to identify different frequencies of characteristics or exposure of ill (cases) and well (controls) persons. Risk factors are typically characteristics of the ill person, such as age, sex, race, socioeconomic status, area of residence, as well as exposures including foods, smoking, medications, illicit drug use, travel history, daycare attendance, or sexual activity. Some factors, such as breast feeding or immunization, may be associated with decreased risk of disease and be protective.

Determining the risk factors that are associated with disease can also lead to identification case susceptibilities that allow the targeting of specific control strategies to a portion of the population. Great care must be taken in making the distinction between concluding that a factor is associated with a disease and a conclusion that an associated factor is related to cause. Analytic studies that evaluate associations may be affected by confounding and by a variety of bias. Inferring causation requires statistical and logical epidemiologic associations, but proof often requires considerable additional study to fulfill Koch’s postulates.

**SARS**

One of the latest of these new emerging infections is the SARS epidemic. Severe acute respiratory syndrome (SARS), an atypical pneumonia characterized by a high rate of transmission to healthcare workers, began in Guangdong Province, China, in November 2002. Subsequent to its introduction to Hong Kong in mid-February 2003, the virus spread to more than 30 countries causing disease in over 7900 patients across 5 continents. In many locations, the infection was spread by ill travelers to healthcare workers and household contacts.\(^5\) The global spread of SARS proceeded with unprecedented speed, overwhelming many hospitals and some public health systems in a matter of weeks. On March 12, 2003, the WHO issued a worldwide alert for SARS. A novel corona virus (SCoV) was identified as the etiological agent of SARS, and the virus causes a similar disease in cynomolgus macaques. Human SCoV appears to be an animal virus that crossed to
humans relatively recently.\textsuperscript{6,7} The SARS virus may long have had the capacity to infect people, but only recently encountered conditions that facilitated its spread.

East Asia was hit hardest by SARS, with China having 5328 cases up to June 2003, followed by Hong Kong with 1753 cases, and Taiwan with 680 cases. This was the fourth time in recent years that an emerging infectious disease has surprised East Asia. The Nipah outbreak in Malaysia,\textsuperscript{8} the enterovirus 71 outbreak in Taiwan,\textsuperscript{9} and the influenza H5N1 outbreak in Hong Kong had all disrupted the regional public health infrastructure before SARS.

Outside of Asia, Canada was the country hardest hit by SARS. As of August 2003, there had been 436 probable and suspect SARS cases in Canada, including 44 deaths.\textsuperscript{10} The majority of SARS cases and all deaths were concentrated in Toronto and the surrounding Greater Toronto area. The toll on healthcare workers was high: more than 100 became ill and 3 succumbed. The SARS experience illustrated that Canada (as other countries) is not adequately prepared to deal with a true pandemic. In response, Canada’s Minister of Health established The National Advisory Committee on SARS and Public Health in early May 2003. The Committee’s mandate was to provide a third party assessment of current public health efforts and lessons learned for ongoing and future infectious disease control. The Committee has accordingly recommended strategies that will reinforce the public health system and integrate its components more fully with each other. The report is extremely interesting and valuable and should serve as a working instrument for many other public health systems throughout the world.\textsuperscript{11}

The impact of SARS on society and the economy was very large, especially in Asia. This type of epidemic is not new, but the media reaction had considerable impact. For society, the investigation of an unfolding epidemic is essential to assess the potential impact and to implement measures to contain it. The insurance business is faced with the same necessities, and to determine early whether it should adapt its business processes.

WEST NILE VIRUS (WNV) EPIDEMIC IN THE UNITED STATES

The 1999 appearance of the WNV in the United States is an excellent example to illustrate the epidemiology concepts reviewed above. The exact manner in which WNV came to the United States remains unknown. However, because it first appeared in a major international gateway (New York City), travel and commerce may have played a major role.\textsuperscript{12} The incubation period of WNV ranges from 3 to 14 days. National surveillance documented persons with illness caused by WNV, mostly encephalitis and meningitis, each year since 1999: 62 persons in 1999, 21 in 2000, and 66 in 2001 (incidence). Only 20\% (attack-rate) of persons infected with WNV developed WNV fever, and only half of these had visited a physician for this illness.\textsuperscript{13} Only 1 in 150 infections resulted in meningitis or encephalitis. The case-fatality rate among patients hospitalized during the outbreak was 12\% in New York. Case-fatality rate is defined as the proportion of cases of a specified disease that is fatal within a specified time and is a measure of the severity of a disease. Advanced age was the most important risk factor for death. Patients older than 70 years of age were at particularly high risk. Among hospitalized patients, more than half did not return to their functional level by discharge, and only one third were fully ambulatory.

From an insurance point of view, the case-fatality rate and the long-term disability are of utmost importance.\textsuperscript{14}

The 1999 New York epidemic is an unsettling reminder of the ability of viruses, including arbovirus, to jump continents and hemispheres. The subsequent spread of WNV virus throughout much of the eastern half of the United States during 1999–2001 emphasizes that arboviruses introduced to new areas can become established if efficient vectors, suitable vertebrate amplifying hosts, and reliable “wintering” mechanisms are avail-
able. The fact that WNV has caused widespread mortality in some North American bird species is a reminder that a virus introduced into a new ecosystem, or new hemisphere, can produce unexpected results. This also demonstrates that even the world’s most affluent cities are at risk for epidemic arboviral disease without sustained control measures for the mosquito vector in urban areas. The intense publicity generated by this outbreak, largely overshadowed the fact that much larger, more deadly and almost equally unexpected urban epidemics of WNV meningoencephalitis occurred elsewhere. These outbreaks included 1 in Russia almost simultaneous to the New York outbreak, in Romania only 3 years earlier, and in Israel only 1 year later.

**THE CASE OF NIPAH VIRUS EPIDEMIC (1999)**

In early 1999, health officials in Malaysia and Singapore investigated reports of febrile encephalitis and respiratory illness among workers who had been exposed to pigs. A previously unrecognized paramyxovirus (formerly known as Hendra-like virus now called Nipah virus), was implicated by laboratory testing in many of these cases.8

As of April 1999, 257 cases of febrile encephalitis were reported to the Malaysian Ministry of Health, including 100 deaths. Laboratory results from 65 patients who died suggested recent Nipah recent virus infection. The apparent source of infection in most cases was continuous exposure to pigs. Human-to-human transmission of Nipah virus has not been documented. Outbreak control in Malaysia focused on culling pigs; approximately 890,000 pigs were killed. Other measures included a ban on transporting pigs within the country, education about contact with pigs, use of personal protective equipment among persons exposed to pigs, and a national surveillance and control system to detect and cull additional infected herds.

**RISKS FOR THE INSURANCE BUSINESS**

Despite the overwhelming amount of media attention given to SARS and WNV, neither disease has reached the critical mass to impact life insurance pricing or routine underwriting practices. However, a major risk from any epidemic for the insurance business is reputation. An overreaction to a perceived major risk, through restrictive underwriting and/or large premium increases can have a negative impact on an individual company, or even the industry as a whole. Conversely, an underestimation of the risk may lead to losses that may have to be shared by all policyholders through dividend reductions or premium increases. The key objective is to maintain a focus on the epidemiological conclusions drawn from the available data and to avoid being distracted by the level of the media reaction. Good data combined with competent analysis is a prerequisite not only for public health, but also for the proper evaluation of insurance risks. These data needs are summarized below.

Life insurance may be influenced by increased mortality. In addition to the basic data, life insurers need to know the attack rates and the case-fatality rates, as well as the demographics of these 2 variables. This data must then be compared with the normal fluctuation of infectious disease prevalence in the affected country. An obvious example is an influenza epidemic, which is probably the biggest biological killer. For in-force business, an assessment is necessary to evaluate a possible increase in reserves. With respect to new business, updated underwriting guidelines may also be necessary to avoid anti-selection. For example, the incubation period of SARS is estimated to be 10 days, which would be a rational time to postpone applications from people thought to be at high risk. The problem is more difficult where high-risk individuals are not easily identified and the incubation period of a disease is very long. With an incubation period of 15 years, bovine spongiform encephalopathy (mad cow disease) for example, can infect its victim some-
time before the disease is identified, making underwriting and pricing practically impossible.

Disability risk is assessed with clinical data concerning the degree of long-term impairment after recovery from the acute phase. SARS does not seem to be linked to a disability risk in the same way as with WNV. However, follow-up studies of SARS patients are needed to investigate this risk. Unfortunately, such studies will not be published until many months, or even years, have elapsed after the peak of the epidemic.

The impact of an infectious epidemic on critical illness insurance products is even more difficult to quantify and will depend on which conditions are covered. The classic illnesses covered by critical illness products, heart attack, stroke and cancer, are usually independent of epidemic infectious diseases. It is feasible that in the future a chronic illness may be attributed to a current epidemic infection in a way similar to the current hypothesis that an unknown infectious agent may be responsible for the development of multiple sclerosis.

**CONCLUSIONS**

The worldwide risks of humanitarian, economic and environmental disruptions due to emerging infectious diseases, invasive species and bioterrorism are increasing in conjunction with intensifying change in biological systems related to human activity. The SARS epidemic has focussed the world’s attention on the explosive spread of new infectious diseases with the economic and societal risks of a global pandemic. At a point in history when global technology capabilities have become so advanced, the defensive tools of the nation-state against a biologic event such as SARS seem crude and limited, and have shaken the global economy.

The SARS epidemic is not a strange and unexpected anomaly; it is an expected event. Its emergence falls in the context of a succession of emerging infectious diseases in human and livestock populations that have captured public attention in recent years. The story of the SARS epidemic highlights essential lessons about the broader economic and societal impacts of these accelerating changes. A deeper analysis of the SARS outbreak sheds light on how human activities are influencing the emergence of infectious diseases, increasing the speed with which diseases spread and with which responses can be fashioned, broadening the scope of biological and economic consequences.

The core skill of the insurance industry is the assessment of risk. In the case of epidemics, it is essential for insurers to look at the risks they present in a rational way, based on sound data. In addition to the usual epidemiological data, insurers need to assess risk groups from a product point of view and possibly implement selection processes to avoid short-term anti-selection during a developing epidemic.

We must keep our eyes open for the first signs of the next challenge and continue to respond in a rational, effective and timely way.

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